Paper presented in the IV Globelics Conference at Mexico City, September 22-24 2008

Globelics

Leader in Production but a laggard in Consumption? Innovation System and IT Diffusion in India's Manufacturing Sector

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1. Introduction

It may be paradoxical that a developing country like India, while having only a negligible share in world trade, has been able to record remarkable export performance, mostly at the instance of domestic firms, in a knowledge intensive sector like IT software and services. and that has attracted world attention. While this achievement is highly laudable, the real return from a General Purpose Technology (GPT) like ICT is accrued when it is harnessed for enhancing the productivity and competitiveness of different sectors of the economy and welfare gains for different sections of the society. In the current era of globalization and intense international competition the ability to reap such returns could help ensure the survival of the developing countries and their catch up. The relevant question in case of India is its success with respect to harnessing the new technology for addressing various development problems. While, there are a number of studies on the use of ICT in agriculture and other service sectors including e-governance, the issue of IT diffusion in India's manufacturing sector has not yet attracted the attention of researchers that it deserves. In this context the present study is an attempt at addressing this issue by making use of a unique dataset on the IT investment in India's manufacturing sector furnished by the Annual Survey of Industries.

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Conventional approach towards analyzing the diffusion process involves estimation of diffusion curves which considers diffusion process analogous to the occurrence of an 'epidemic disease' within a population (Rogers 1962). Such analyses, cast mostly in the neoclassical framework involves analysis of the time path of the technology adoption process by estimating the sigmoid or S shaped curve. Most of the studies in this tradition (see Karshenhas and Stoneman 1995 for a survey) also indicate that inter-firm diffusion differs across industries and technologies and has highlighted a number of technology specific, adopter-specific and other factors like the environment in which the adopter operates that influence the diffusion process. Apart from the greater focus on demand side factors at the cost of supply side factors influencing diffusion process, it is also assumed that technology remain the same during the diffusion process. More importantly, these traditional analytical models fail to take care of the changes that take place in the environment wherein the diffusion process and those that occur at the original innovation itself (Freeman, 2003). In the evolutionary theory, that forms the theoretical foundation for the innovation systems approach, approach Nelson and Winter (1982) rejects the models that assume full information and classical rationality and instead postulates limited information and bounded rationality. They sustain that both the course and the rhythm of the diffusion process are not easily given, and are intertwined with a combination of elements such as: organizational routines, profitability expected by firms of the sector; consumers' preferences and existing regulatory devices, as well as the imitation process. This paper follows the innovation system perspective to address the issue at hand.

India is one among the pioneering developing countries to make conscious attempt towards developing a broad based and technologically dynamic electronics, computer and software industry as early as in the mid1960s. To the extent that supply side factors are equally important in shaping the diffusion process, these initiatives could be viewed as attempts at accomplishing certain element of innovation system to help diffusion of technology into the user industries. However, in the early years of its development, the Indian strategy, in line with the then general industrial strategy, aimed at an import substituting, self reliant and public sector-led growth under the umbrella of government

protection and regulations. Towards the close of the 1970s and in particular during the early 1980s, there was the initial wave of shift in strategy as manifested in the series of policy reforms oriented towards making the industrial sector more competitive followed by the globalization policies of the 1990s wherein there was unprecedented thrust of export orientation and institutional arrangements to accomplish the same. It is true that in India the diffusion of technology has been recognized as important for economic growth and welfare in the Science Policy Resolution of 1958[3] which formed the corner stone of India's innovation system. Yet it is important to explore how the different elements of innovation system the innovation system that evolved over the years have been instrumental in facilitating the diffusion of innovations in general and high technology innovations like ICT in particular.

IT software and service sector: Emerging trends

During the early years of its development, the software and service exports from the country was carried out mostly in the form of onsite development (Heeks 1996) displayed very low level of capability focusing on the low end of the value chain. As a result, the revenue per employee in 1993 was only $ 6,200 (Athreye 2005) which only a fraction of that of Israel and Ireland (Arora et al 2000). Moreover, the net export earning has been only of the order of 50 per cent of the gross exports of software and services (Joseph and Harilal 2001). However, there are indications to show that the IT sector, over the years, has not only undergone significant structural transformation but has built up substantial technological capability.

With the setting up of a number of Software Technology Parks, which inter alia provided access to modern telecommunication facilities, and liberalized policies towards the telecom sector, which in turn led to the entry of a number private sector telecom companies, there has been a significant shift away from onsite development. Today

[3] It was explicitly stated that the key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and **adoption** of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital.

nearly 70 per cent of the exports take the form of offshore development which was only about 20 per cent in the 1980s.

There are evidence to indicate that the Indian companies have developed domain expertise in a wide range of domains and industries. Banking, insurance and finance has emerged as areas in which they have developed particular expertise and have even launched packaged software. An evidence of the growing ability and expertise of Indian software companies was provided by their ability to manage transition from Y2K-related projects successfully. This transition has been managed because of their ability to quickly diversify into Internet and e-commerce related technologies and applications that are now booming. According to surveys conducted by CMU, the expertise levels of Indian companies on UNIX and Windows NT platforms is considered to be on par with US firms. Indian companies have also grown in their ability to handle larger and more complex projects than in the past (Arora *et al*. 2000). Now 300-500 man-year projects are not a rarity any more. As a result the revenue per employee has been estimated at $35,129 in 2000 (Athreye 2005) and the trend continues.

A number of Indian companies have managed to enter into the area of software development and the sales from software products accounts for a substantial part of their revenue and exports. A niche market has been created in banking, financial and accounting software. These include, for instance, I-Flex that has been used by over 240 financial institutions in 69 countries. Polaris developed a proprietary retail banking software, Polaris Point and is tying up with Bull, France for its marketing in Europe. Banking solutions from Infosys (Financle, Bankaway, and Payaway) have been adopted by 22 domestic and 16 overseas banks across 12 countries as early as in 2001. TCS launched packaged software for banking insurance, securities, accounting, and health care industries. TCS also launched its branded integrated suite of software tools Mastercraft which is claimed to have been received well in the US and Europe and carries a price tag of US $ 150,000. WIPRO Technologies launched a number of branded products including Teleprodigy, a billing system for ISPs, and WebSecure, an Internet

security package. It is focusing on global brand building and plans to come up with a branded product every year (Kumar 2001 Joseph 2007).

With the MNCs increasingly look for complementary capabilities, Indian firm are increasingly getting engaged in highly skill demanding areas like chip design and R&D and thus are moving up the value chain marked by a shift away from Business Process Outsourcing to Know Process Outsourcing. Now the firms are increasingly entering into high end consulting, engineering and R&D services with the development of domain expertise and export of packaged software. As result the share of high value adding and innovative segments - that include engineering services, R&D and software products – in the total value of output and export is estimated to have reached a level of 4.8 per cent 3.9 per cent respectively in 2005-06

International orientation and the increasing professionalism of Indian software enterprises has prompted them to align their processes with global best practices and to obtain international certifications. In 2005-06 among the 401 firms that reported different international quality standards 82 had SEI CMM level 5, the highest level of quality accreditation across the globe, which that accounted for more than two-thirds of such firms in the world over. As many as 123 firms had SEI CMM level 2 certification or above and 330 had ISO 9001 (Joseph 2007).

Since the conventional measures of innovation like R&D intensity (measured as Research expenditure as proportion of sales) has certain limits in capturing innovation in a service sector like IT, a study by Joseph and Abraham (2005) developed an Index of Claimed Technological Competence (ITC) using firm level information on their areas of specialization. The theoretical base of the index has been drawn from the literature on technological opportunity. The estimated index revealed an upward mobility of firms. To illustrate, in 1998 over 56 per cent of firms were in the low index category (less than 30%) where as in a short span of three years the share of such firms declined to around 44 per cent. Similarly in the higher index category (greater than 60%) the share of firms increased from 5.3 per cent in 1998 to 8.3 per cent. in 2001. The estimated index of

leading IT firms like Infosys, Wipro, TCS and Satyam were found to be more than 75 per cent. Thus, notwithstanding any significant increase in the R&D intensity of firms there appears to have been an upward mobility of firms in terms of the estimated ITC.

The observed structural change and capability building has also been reflected in the growth performance of this sector. The recorded annual compound growth rate has been over 50 percent in the 1990s and 38 per cent since 1997-98 and such a record has been unprecedented not only in independent India but also in the world. As of now the software and service exports is over 20 per cent of merchandise exports and even higher than one of India's principal commodity in India's exports viz. textile and textile products. Needless to say the remarkable export performance has attracted the attention of researchers and well documented in the literature (Kumar 2001a, Kumar 2001 Arora et.al 2001, Joseph and Harilal 2001, Parthasarathi and Joseph 2002, Joseph 2002, Kumar and Joseph 2005, Joseph 2007 to list a few).

Having established the credibility in the export of software services, of late the Indian firms have emerged as the major players in business process outsourcing (BPO) through IT Enabled Services (ITES). Thus ITES has emerged as a more dynamic component of software and service exports from the country. In 1999-00 the total ITES exports was only of the order of $565 million. According to the revised estimates by Nasscom, the ITES exports increased from $3.1 billion in 2003-04 to US $ 4.6 billion in 2004-05 recording a growth rate of 48 per cent and are estimated to reach $ 6.3 billion by the end of 2005-06. As a result, the share of ITES in total software and service exports almost doubled from about 14 per cent 2000 to 27 per cent in 2006.

The share of IT software and services in GDP has recorded a four fold increase from about 1.2 per cent in 1997-98 to 4.8 per cent in 2005-06. By way of comparison, Chandrasekhar et al (2006) finds that IT revenues in 2004-05 were about 20 per cent higher than construction sector and almost three times higher than in mining and in electricity, gas and water supply. What is more gross revenue from IT services exceeded

12 per cent of GDP generated in India's service sector that accounts for about 54 per cent of the GDP.

Innovation System in India and IT diffusion

It is by now well recognized that India's performance in the IT sector has been inked closely with the innovation system evolved over the years. However, existing explorations on the bearing of innovation system in general and that of state in particular, on the performance of IT sector has been in the context of its remarkable export performance. How has the innovation system been influential in shaping the diffusion of ICT in different sectors of the economy? To the best of our knowledge, this issue has not yet been subjected to detailed inquiry. Hence in this section by following a broader approach to innovation system (Lundvall) we shall examine the innovation system to highlight its influence on IT diffusion. More specifically, we shall take up different element of innovation system in terms of their bearing on production vis a vis use of IT. As already stated the focus of discussion will be on the industrial sectior.

Human capital

The single most important element of India's innovation system that could help both production and diffusion of IT is the human capital. Studies have rightly indicated that the availability of skilled manpower at low cost provided an initial advantage for India in the world market. (Heeks 1996, Kumar and Joseph 2006) However, as argued by Athreye (2005) the sustenance of India's international competitiveness needs to be seen in terms of higher productivity of India's IT professionals. This in turn, has been an outcome of various policy measures and institutional interventions by Government from the late 1960s at the instance of the Department of Electronics, later known as Department of Information Technology. For example in the early 1970s the Department of Electronics (DoE) estimated the need for about 300 M.Techs and 50 PhDs in computer science and

technology and called for specialized Masters level programmes at the IITs and other major institutions. Besides the various courses started at the educational institutions, a number of enterprises and other institutions promoted by DoE have also been providing training in software development. These include NCST and C-DAC (Centre for Development of Advanced Computing) running advanced software engineering courses and CMC Ltd., ETTDC, NIC running routine software application training.

Besides these, the government permitted private investment in IT training since the early 1980s. About 80 private companies have been operating some 4,000 training centers by 2000 offering various IT courses throughout the country through networks of franchises. These privately run centres offer diplomas of various duration, ranging from short-term specialized courses to longer-term basic courses. Some of these private companies expanded their training outside India and by 2004 Indian firms were found offering IT training in 55 countries. What is more, the leader NIIT has been operating more than 100 training centers in China.

However, the quality of the training imparted by these institutions had been uneven. DoE has stepped in to provide accreditation of their courses as a step towards standardization of these courses. A scheme called DOEACC was started in 1990 to provide accreditation to specified level of courses viz., O-foundation course, A-Advanced Diploma, B-MCA Level, C-M.Tech Level. DOEACC Society accredited about 699 institutes by January 2000. The Society conducts examinations for all the four levels twice a year and grants certificates /diplomas (Kumar and Joseph 2006).

The demand for software personnel especially engineering graduates has grown rapidly since the mid 1990s due to the expansion of the software development activity in India as well as the growing brain drain. In view of this, easing the supply of IT professionals has been one of the challenges faced by the country. In a survey conducted during the late 1990s, 57 per cent of the firms interviewed indicated manpower and skills shortage as the major problem (Arora *et al*. 2000). In a context of IT manpower shortage the National Task Force on IT and Software Development (NTITSD) made a number of

recommendations dealing with augmenting the quality and quality of trained manpower for software industry. In tune with these recommendations, the capacity of the higher education system in engineering in the country has been expanded besides setting up of new institutions like the National Institute of Information Technology.

The emergence and growth of software sector in Bangalore highlights the role of human capital in a clear manner. Though the state of Karnataka has only 5 per cent of India's population it has nearly 15 per cent of its higher education enrolments. Karnataka had 83 engineering colleges under Vishweshvaraiah Technology University offering the Bachelors of Engineering degrees.5 Of these, 25 colleges were located in Bangalore; 59 are in the Bangalore region. There are eight other non-engineering universities, two of which are in Bangalore. Bangalore University itself has over 50 colleges located within Bangalore. Though not a source of engineers, these colleges contribute to English-speaking science and IT-proficient graduates (D Costa 2006). Karnataka has two of the nine national institutes of technical education including the Indian Institute of Information Technology (IIIT) and the established Indian Institute of Science (IISc), two of the 43 regional engineering colleges, 12 per cent of the country's degree colleges under universities granting technical degrees, and 15 per cent of diploma-granting polytechnics (Okada 2004: 298). No wonder Bangalore has emerged as the IT capital of India

Thus viewed, Innovation system in India has been instrumental in the generation of skilled manpower and thus setting the initial conditions for the promotion of high technology innovations like IT and its diffusion. However, deployment of such manpower for production vs diffusion of IT had to be seen in terms the incentive systems that existed which in turn crucially depended on the behavior of other elements of the innovation system

Policy framework at the national level

In contrast to the general perceptions, Parathsarathi and Joseph (2002) argue that the importance of promoting software development had been recognized by the erstwhile

Department of Electronics (DoE) and suitable policies and programs were put in place as far back as 1972. In a period when very high tariff and non tariff barriers were the rule, import of computer systems on a custom duty free basis and with out reference to indigenous angle clearance was permitted for software export. Moreover, in a period when there were series of restrictions on FDI, 100 per cent foreign owned companies were permitted to set up software export operations provided they locate in the Santacruz Electronics Export Processing Zone (India, Department of Electronics 1972).

A series of government committees and policy measures have contributed to the evolution of the Electronics industry in general and IT and software in particular. The early initiatives include Bhabha Committee of 1963, Electronics Committee Chaired by Dr V.A. Sarabhai in 1966, and the National Conference on Electronics of March 1970. Significantly, the National Conference had recognized the potential of India to emerge as a force in software exports. As a follow up of their recommendations, a separate Department of Electronics (DoE) was set up to coordinate and implement policies for development of electronics industries including computer software in 1970. In 1971, the government constituted the Electronics Commission as a policy formulation body with a heavy emphasis on R&D and technology development.

In 1969 a computer group was set up in the Electronics Corporation of India Ltd (ECIL) to design, develop and manufacture a wide range of components, instruments and computer systems and to develop the needed software, which laid the beginning of indigenous efforts towards the development of computer and software industry. In 1972 the government appointed the Mini Computer Panel with a view to study the local technological capability in the manufacture of mini computers, the demand for such systems and the foreign exchange implications (Joseph 1997) The panel made wide ranging recommendations regarding the product configuration as well as software development and designated different agencies for the development of software, peripherals and computer systems (see for details DoE 1974). In the late 1970's with the exit of IBM, Government set up the Computer Maintenance Corporation (CMC) which later emerged as a leading software unit that developed wide range of major software

systems both for the domestic and export market (see for details Parthasarathi and Joseph 2002).

During the late 1970s and early 1980s, various studies were undertaken at the instance of electronics commission to explore the economic and technical viability of computer application in various Indian industries[4].

The Computer Policy of 1984, gave a thrust to software development by underlining the need for institutional and policy support on a number of fronts. The policy, for example, called for the setting up of a separate Software Development Promotion Agency (SDPA) under the Department of Electronics (DoE). Imports of inputs needed for software development were made more liberal among other initiatives (Government of India 1985)

The accelerated growth of computer industry following the above policy posed numerous problems for the software activities calling for a rationalization of the policy for import and domestic production of software and using this base for promoting software exports. At the same time, world trade in computers was expected to be of the order of US $100 billion by 1990 where in more than half was estimated as software. The seventh five year plan for electronics had a software export target of US $ 300 million accounting for about 0.6 per cent of the world trade in software. Against this background an explicit software policy was announced in 1986 and software was identified as one of the key sectors in India's agenda for export promotion. The policy underlined the importance of an integrated development of software for the domestic and export markets (Government of India 1986).

With the initiation of economic reforms in the early 1990s the Finance Ministry made an assessment that apart from the general orientation of all industries towards export markets, India’s comparative advantage was in the software and not in the hardware. Therefore, a major thrust was consciously given to software exports. Accordingly, new policy measures

[4] These reports were published in a journal called Electronics Information and Planning published by the Department of Electronics

have been initiated which *inter alia* included; removal of entry barriers for the foreign companies and removal of restrictions on foreign technology transfers, participation of the private sector in the policy making, provisions to finance software development through equity and venture capital, measures to make available faster and cheaper data communication facilities, and reduction and rationalization of taxes, duties and tariffs etc[5] (Narayana Murthy 2000).

Recognizing the potential of IT-related industries and software for India's development, the Prime Minister appointed a National Taskforce on Information Technology and Software Development (NTITSD) in May 1998 under the chairmanship of the Deputy Chairman, Planning Commission. NTITSD submitted its report outlining a National IT Plan comprising 108 recommendations for the software and 87 recommendations for the hardware (India, NTITSD, 1998). These recommendations have since been notified by the Government in the Gazette of India dated 25 July 1998. NTITSD has set before the country an ambitious target of $ 50 billion software export by 2008. DoE was upgraded into a full-fledged Ministry of Information Technology (MIT) in October 1999 to coordinate the promotional role of the government in the industry[6].

Despite the series of policy measures to promote the development of IT, India being a labour abundant country and on account of the generally held belief that computers are labour displacing, the use of computers, especially during the early years, was explicitly discouraged. In 1969 the Ministry of Labour, Employment and Rehabilitation set up a high level committee to advise the Government on computerization. The resolution sitting up the committee noted the following:

"Government's policy in this regard has been that automation could be introduced as a selective basis…… The criteria which determined such selectivity need to be more clearly defined and for this purpose the government have decided to set up a committee" (as quoted in Subramanian, 1992:13).

[5] Mention need to be made of the substantial reduction in the duties and tariffs across the board for components and sub assemblies, zero duty of software import and zero income tax on profits from software exports.

[6] See India, MIT (2000) and http://www.mit.gov.in for programmes of the Ministry

The committee favoured a positive approach and recognised the legitimate use of computers in the fields of education, science, defence and even in some commercial and industrial establishments. But the strict regulatory measures that they prescribed were contrary to their positive approach. It was laid down that all the computerisation proposals had to be scrutinized by two experts, case by case and a justification report furnished.

In 1979 during the first meeting of the reconstituted electronics commission, the cabinet secretary and the finance member reported the fear regarding computerisation leading to unemployment. As late as in 1984, while the government adopted a liberalised policy towards computer industry, the approach of government towards use of computers had not undergone any major change. To a question raised in the parliament on use of computers in 1984, it was stated that the policy announced in 1978, which was highly restrictive, continued to be the basis for the induction of computer technology in India[7]. While the then Prime Minister Rajiv Gandhi firmly believed in computers as a tool of productivity enhancement and national development, the government was hesitant to openly declare a policy that promote the use of computers across different sectors of the economy. Though the policy on software export announced in 1986, underlined the need for promoting both export and domestic use of software, the policy did not highlight any specific measures to promote the use in domestic economy (Joseph 2005).

More over, trade policy regime governing the IT sector, similar to other sectors, till recently was characterized high tariff barriers and domestic taxes that in turn led to higher process in the domestic marker. While tariff exemptions were offered for those firms engaged in exports, such concessions were not available to the domestic users of information technology. Thus viewed, the fear of laour displacement by computers along with high cost of hardware and software would have acted a deterrent to the use and diffusion of IT on the industrial sector.

[7] Ram Vilas Paswan, 'Computerization Policy in the Country', IPAG Journal, Vol. 11, 11, New Delhi, August 1984, p. 742, Lok Sabha Question, No, 4142, answered on 21 March, 1984.

Regional level policies

In India many of the factors that govern the innovation and diffusion of technologies like IT are under the jurisdiction of the regional (state) governments. These include, the human capital availability, infrastructure facilities like roads, electricity, procedures relating to land acquisition labour and employment and various taxes like sales tax. Hence different state governments, beginning with the state of Karanataka, have passed IT policies to address these issues. Today, as many as 19 states have IT policies of their own. Some of the states like Karanataka, Andhra Pradesh and Tamil Nadu have separate policies to attract investment into the ITES sector, addressing issues specific to this sector.

With respect to manpower the policies in general underlines the need for making available an ample supply of quality manpower wherein the private sector is given an important role. In the respect the policies also underlines the need for greater interface between the academia and the industry[8]. By harnessing the Software Technology Park scheme initiated by the national Government, and the presence of multiple telecom service providers, all the state Governments have taken measures to provide better communication facilities. Also incentives are provided to attract more telecom service providers to respective states.

The policies in general are oriented towards enhancing the export competitiveness of firms and underline the need for the firms to acquire quality certification and some of the

[8] In Andhra Pradesh, for example, the policy states that the state will institute a two-tiered training programme to address the manpower needs of the ITES companies. The first level of this training programme, required for all potential ITES employees, will be geared towards augmenting basic english capability. The second level of this programme will focus on specialized skills for ITES. Further, the policy also provides for value-added elective courses for domain specific skills such as HR training, payroll processing, insurance processing, GoAP laws, etc. in the second level of training.

states have even provision to provide financial support to obtain the needed certification. The Software and service firms have been exempted from the environment clearance and the single window clearance scheme is prevalent in almost all the states. Also the units are assured of uninterrupted power supply.

Most of the state governments have made necessary amendments to the existing labour laws to facilitate three-shift operation, employment of women during 6 pm to 7am and to follow flexi timings. ITES services have been brought under the essential service Act and even states like Kerala have made provision for self-certification with respect to following imports acts like the Factories Act, The Employment Exchange (Notification of Vacancies Act), The Payment of Wages Act, The Minimum Wages Act, The Contract Labour (Regulation and Abolition) Act, The Workmen Compensation Act, The shops and Establishments Act and the The Employees State Insurance Act

In addition all the state governments are providing a number of fiscal incentives and additional incentives have been offered to attract investment into less developed regions in the state and units with larger investment and those generating more employment. The incentives include, but not limited to, concessions on stamp duty and relaxations on registration charges, exemption from payment of entry tax on all capital goods required for implementation of the projects, capital subsidy of the order of not less than 20 per cent, interest subsidy, employment subsidy (mostly linked to number employed), tax holiday and so on.

A perusal of the various fiscal incentives today offered by the state governments tend to suggest that there is an intense “incentive competition” among states to attract more investment. In the context of competition among developing countries to attract more FDI by offering greater incentives, UNCTAD (1995) has shown that such wasteful competition are detrimental to the interest of the developing countries. Such a conclusion appears to be relevant in case of ongoing competition among various state governments to attract more investment. Various studies have shown that in deciding the investment location by MNCs the incentives do not necessarily play an important role (Kumar 2002).

Given the fact that India has certain comparative advantage in skill intensive areas like software and services, the focus of policy measures needs to create a facilitating environment by creating better infrastructure and other facilities instead of entering into wasteful incentive competition. Such investment facilitation becomes all the more important because as shown in the forthcoming section, even today, only a fraction of the total number of foreign investment approvals finally gets realized. Thus the social marginal product of a rupee spent on creating needed infrastructure and other facilities are bound to be more as compared to that spent towards providing incentives to foreign firms. Also, in the IT policies of most of the regional governments, the domestic use of IT and the ways and means of bridging the digital divide seems to have not received the attention that it deserves.

IT Infrastructure

Another important element of the innovation system with bearing IT development related to the IT infrastructure, which in turn include but not limited to, infrastructure for technology development, communication infrastructure and software technology parks

With respect to the infrastructure for technology development, it may be noted that as early as in the 1970s, following the recommendation from the National Conference on Electronics. DoE established Regional Computer Centres which were operated like public utilities, attached to educational institutions. These centres were set up at Bombay, Delhi, Bangalore, Calcutta, Kanpur, and Hyderabad. Computer Maintenance Corporation (CMC) was set up in 1976 for maintaining these computer centres. Over time CMC has grown into a full fledged software company with strong R&D capability. National Informatics Centre (NIC) was set up to facilitate automation and networking of government offices at the centre, state and district levels.

Since the late 1980s, the DoE has concentrated on providing data communication and networking infrastructure to the educational and research community and to the software industry. This infrastructure has played a critical role in the development of the industry in the 1990s. The Education and Research Network (ERNET) project was initiated in 1986 with participation of NCST Mumbai, IISc Bangalore, five IITs, with the support of

DoE and the UNDP with a view to enhancing the national capability in the area of computer communication by progressively setting up a nation-wide computer network for the education and research community. ERNET has evolved into a separate institution now providing networking services to over 80,000 users in 750 academic and research institutions with its dedicated satellite data transfer backbone.

Yet another infrastructure related to the setting up of software technology parks established and registered as an autonomous society under the Societies Registration Act 1860, under the Department of Information Technology, Ministry of Communications and Information Technology in 1991. STPs provide infrastructure facilities including High Speed Data Communication (HSDC) links and single window clearance system. It enables export oriented software firms to conduct exports operation at a pace commensurate with global standards. Companies in these parks can import goods duty free and for the first five years without corporate taxes. The parks have centralized computing facilities and members get complete access to high speed data communication links and the internet. STPI, as of now has over 40 centers spread across the country and helping about 6500 software exporting companies accounting for nearly 95 per cent of the total software export.

Realizing the importance of telecommunication in overall development of the economy in general and that of IT and Software service sector in particular, the government initiated a number of policy reforms that helped creating a highly competitive environment leading to drastic reduction in telecom cost but also in increased access and better quality services. Perhaps the first step was the announcement of the National Telecom Policy in 1994, opening up the telecom sector to competition in Basic Services as well as Value Added Services like Cellular Mobile Services, Radio Paging, VSAT Services etc. It also set target for provision of telephone on demand and opening up of long distance telephony. This was followed by the Telecom Regulatory Act of 1997, which led to the establishment of an independent Telecom Regulatory Authority of India (TRAI). Later a New Telecom Policy of March 1999, south to remove some of the bottlenecks and move the liberalization process forward[1] These policy reforms have

resulted in the fastest expansion of the telecom network in the country. This has been possible because of opening up of all the telecom services for the private sector without any restriction on number of operators except for the cellular mobile phone segment due to frequency constraints. Private sector investment has been helping in bridging the resource gap to a considerable extent as was envisaged (Department of Telecom. Annual Report 2002-03).

Industry associations, firms and other actors

The development of the IT software sector in India has been mostly at the instance of local firms. While some of the pioneering ones like Tata Consultancy Services belonged to the large business houses, some of the most dynamic ones like Infosys belonged to entrepreneurs with prior IT experience and they accounted for nearly 37 per cent of the IT sales (Athreye 2005). While India's ICT success has been by and large home grown almost all the leading foreign IT companies have their presence in India. The entry of Citicorp Overseas Software Ltd. (COSL) in Bombay in 1985 and of Texas Instruments (TI) in Bangalore in 1986 highlighted India's potential to outside MNEs. Subsequently, a number of other western corporations began to follow the footsteps of COSL and TI, such as HP in 1989 and followed by Novell, Oracle, among others. Seeing the potential, a number of Indian companies engaged in the manufacture of computer hardware started to spin-off their software divisions (Heeks, 1996, for more details). The use of satellite links for data communication by TI's development centre in Bangalore in 1987 also served to demonstrate to the government the critical importance of providing satellite data communication links for software exports from India (Kumar 2001). Hence the government started to provide the high-speed communication links in the STPs.

By 2003-04 112 of the 572 member companies of NASSCOM were reported as foreign companies. Although many of the large MNEs have established development base in India, their focus has been the export market. Apart from firms, both local and foreign, the other major actors are the industry associations. While the state initiatives laid the foundation for faster growth, the industry associations[9], particularly the National

[9] To begin with, there was the Computer Society of India, which is essentially an association of academics

Association of Software and Service Companies (NASSCOM) played an important role. In addition to lobbying at the Central and State governments levels, the NASSCOM also played a key role in projecting India's image in the world IT market. For example, in 1993 NASSCOM appointed a full time lobbying firm in Washington. It facilitated the participation of Indian firms in a large of international IT exhibitions and projecting India's capabilities in the sphere of IT. Role that NASSCOM played in getting the visa rules relaxed by the developed countries, especially USA, is well known. Also, in 1994 NASSCOM initiated the anti piracy initiatives in India, when IPR was becoming a major issue in the Indo-US relations (Kumar and Joseph 2006). It took up the campaign against software piracy and conducted a number of well-publicized raids[10]. In recent years, in the context of shortage of skilled manpower, NASSOCM has joined with UGC and leading firms to promote interaction between industry and university on the one hand and setting of finishing schools. These measures, while helpful for the development of IT sector in India, have been primarily oriented towards building export competitiveness and IT diffusion in the domestic economy has been taking a back seat.

Diffusion of IT: Trends and patterns

In the economic analysis of technology diffusion the key issue relates to the process by which an innovation is spread over time and across space among its potential users. Thus viewed, the primary issue is to understand first the extent of adoption (number of adopters at any point in time) that we denote in this paper as adoption rate. In the present context, there is also the need to explore another related issue. Having decided to adopt the technology, how intensively the technology is used by the firm. The adoption rate is estimated as the number of firms making any investment in IT goods and services as a

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and professionals and did not address many of the issues faced by the industry. Hence a new association called Manufacturers Association of Information Technology (MAIT) was formed in 1982. This consisted both the hardware and software firms. Later an association, currently known as Nasscom, was formed to address specific issues being faced by the software and service companies. The Electronics and Software Export Promotion Council, an autonomous body under the MIT, though its various, initiatives also made significant contribution towards India's IT export growth.

[10] For a detailed account of the Nasscom activities in promoting IT, see " Power Lobbying", *Business India*, February 19 to March 4, 2001.

share of total number of firms in the industry. The firms represent the organized segment of the manufacturing sector that comes under the purview of the Annual Survey of Industries. To analyse the intensity of IT use we estimated three indicators: Average Real IT investment per Factory; Share of IT investment in Gross Fixed Capital Formation; and IT investment per Worker. The first indicator of intensity, IT investment per factory provides us a picture of the average size of IT investment per production unit. The other two indicators represent IT investment in relation to the two factors of production, capital and labour. This relation of IT investment as a proportion to the other factors of production would help us to understand the extent of substitution of traditional capital and labour with that of information technology, an important dimension of the diffusion process. In the analysis that follows we shall present a picture of diffusion from the perspective of adoption rates and intensity of use using each of the indicators mentioned above. Finally, we shall also examine the observed trends and patters across different industries at two digit level of aggregation.

IT in the Manufacturing sector:

The share of firms in the organized manufacturing sector that reported any investment in IT was found to be nearly 34 percent in 1997-98 (Table 1) the first year for which the data is available. From 1997-98, there has been a steady increase in the per cent firms reporting IT investment and by 2004-05 their share increased to 52.3 per cent. This represents an approximately 20 percent increase in a short period of seven years. The observed diffusion rate during the last seven years emerges as impressive when considered against the fact that the first commercial computer installation was in 1961 by ESSO Standard Eastern Inc an eastern affiliate of the American multinational oil company Exxon (Subramanian, 1992)[11]. While rate of diffusion increased by 34 percent during the first 36 years, the terminal seven years recorded a much higher diffusion rate of 20 per cent.

The real investment in IT per factory had increased from Rs 0.25 million per factory in 1998-99 to Rs 0.845 in 2004-05. However, this rise in the investment per factory had

[11] The first computer installation in India was at Indian Statistical Institute, Calcutta in 1955.

been mostly due to the falling price in the IT goods and services, rather than any additional investment increase during this period. This is evident from the fact that IT nominal investment per factory recorded a growth rate of only around 4 percent during the period under consideration – a rate of growth much lower than both manufacturing investment and output. The IT investment intensity, measured as a share of IT investment in Gross Fixed Capital Formation shows that it had remained more or less stagnant at around 9 to 10 percent during the entire period, after an increase from 6.7 percent in 1998-99 to 11.8 percent in 1999-2000. The IT investment per worker also was more or less stagnant at approximately Rs. 4500 per worker after the increase from Rs 2680 in 1998-99 to Rs. 4374 in the next year.

Below given in the last two rows of Table 1 are the annual average growth rates of the indicators for the period 1998-99 to 2004-05 and 1999-2000 to 2004-05 respectively. The second growth rate is more representative of the performance of the period. The first growth rate is much higher than the second growth rates, because the reported levels of all indicators is much lower in the period 1998-99. There is a sudden spurt in the levels of all indicators mentioned between 1998-99 and 1999-00, which distorts the average growth if we take the overall period. The year 1998-99 was the first year of collecting such data by ASI. Probably there has been some underreporting in this year, which got rectified from the next year onwards.

For comparative purposes we take the period 1999-05 as the relevant growth rates. Here, the IT adoption rates are growing at the robust rates of 7.5 percent per annum. The real IT investment per factory was also growing at high rates of nearly 13 percent per annum and the growth at nominal rates was 4.5 percent. While the other indicators of IT investment intensity are growing at much lower rates of -3.2 percent and 4.2 percent for the Share of IT investment in Gross Fixed Capital Formation; and IT investment per Worker respectively. This points to the fact that while IT adoption rates and per factory IT investment rates are increasing substantially, the IT investment share in GFCF and IT investment per worker is stagnant or slow.

Table 1: Indicators of IT Diffusion in Indian Manufacturing Sector

Year	IT Adoption Rate (%)	Total IT Investment (Rs Lakh)	Real IT Investment per Factory (Rs Million)	Share of IT investment in GFCF (%)	IT investment per Worker (in Rs)
1997-98	34.2		-	-	-
1998-99	33.1	2566.3	0.25	6.72	2680.68
1999-2000	36	3812.2	0.478	11.82	4374.07
2000-01	40.3	3538.4	0.468	9.94	4727.36
2001-02	44.1	4153.1	0.451	10.5	4495.78
2002-03	46.9	3462.9	0.529	9.82	4406.11
2003-04	49.6	3925.0	0.9.2	8.57	4773.36
2004-05	52.3	5011.4	8.45	9.11	5474.45
GR 1998-05	8.28	13.61	34.02	5.08	14.89
GR 1999-05	7.54	5.24	12.77	-3.82	4.19

The apparent high growth in the IT investment per factory is essentially size effect, wherein, the average size of the factory is increasing, correspondingly IT investment per factory also increasing. This is evident from the Table 2 where IT investment in the small sized firms, with average Real Net Value Added of less than Rs 5 million had an average IT investment of less than Rs 0.08 million rupees, while in large sized firms of size more than Rs 20 million had an average IT investment of nearly Rs 0.2 million. Moreover, the growth of IT investment has been mostly concentrated in the largest size segment of factories, above Rs 20 Million factories at 12.4 percent, compared to near stagnation of IT investment in smaller sized firms. Coupled with this is the fact that the share of smaller firms in the organized manufacturing sector had been declining during this period. During 1998-99 to 2002-03 the growth of firms with less than Rs 10 million capital was negative, indicating a fall in the number of firms (Table 3). While the number of large sized firms, especially the largest sized firms above Rs.100 million capital size grew the most, at 4.12 percent.

Given these evidences on the average IT investment per factory, high growth in IT investment per factory can be taken to be a size effect. However, the other indicator of IT diffusion, share of IT investment in GFCF had declined during this period, clearly pointing to a stagnation or even retrogression in the intensity of IT use in Indian

manufacturing sector. However, given the fact that the total real investment in IT in the manufacturing sector had been growing annually at the robust rate of 5.24 percent during

Table 2 Real Net Value Added per Factory and IT investment (Rs Lakhs)

	Real Net Value Added (Rs Million)			
Year	Less than 5	5 to 10	10 to 20	above 20
1998-99	0.54	1.28	2.19	8.22
1999-2000	0.61	1.60	3.98	14.36
2000-01	0.69	2.64	3.94	17.67
2001-02	0.69	1.68	4.34	15.16
2002-03	1.36	1.46	3.99	16.52
2003-04	0.90	1.19	3.12	35.02
2004-05	0.84	1.79	3.80	25.07
Total	0.80	1.68	3.62	19.65
GR 98-99 to 04-05	7.8	5.6	10.4	29.3
GR99-00 to 04-05	6.4	2.0	-0.7	12.4

Table 3: Number and Growth of Firms according to size of capital

	Size of Capital (Rs Lakh)					
	upto 50	50 -100	100-200	200-500	500-1000	above 1000
GR 1998-03	-1.01	-1.43	1.00	3.38	1.92	4.12

the period, it can be inferred that the decline in the share of IT investment in GFCF is a relative decline, in the sense that GFCF grew faster than IT investment. This growth in the GFCF has ultimately led to the increasing capital labour ratio (Table 4). The capital labour ratio increased from 4.63 in 1998-99 to 5.29 in 2004-05 growing at the rate of 2.38 percent per annum. The rise in capital labour ratio was also related to a decline in the growth of employment per unit of Net Value Added. Whereas in 1998-99 the generation of a unit of NVA required 1.07 units of labour, in 2004-05 the corresponding employment generated had declined to 0.87 units, growing negatively at -0.53 percent, this ultimately led to the stagnation of employment growth in the manufacturing sector growing at 0.58 percent per annum. It is this stagnation in employment that had led to the growth of the ratio of IT investment per worker at more than 4 percent (Table 1). To the extent that IT acts as a substitute for routine labour, the growth of IT investment per

worker need to be understood in the context of stagnant employment growth and rising capital labour ratio.

Table 4: Employment per unit of NVA and Capital- Labour Ratio

	Total Employment (in thousands)	Employment per unit of NVA	Capital Labour Ratio
1998-99	8352.1	1.07	4.63
1999-2000	7903.3	0.90	4.63
2000-01	7752.9	1.00	4.68
2001-02	7511.5	0.90	5.19
2002-03	7698.6	1.07	5.47
2003-04	7630.2	0.88	5.64
2004-05	8178.3	0.87	5.29
Total	5.50E+04	0.95	5.08
GR 98-99 to 04-05	-0.30	-2.68	2.05
GR99-00 to 04-05	0.58	-0.53	2.38

Considering the fact that of the three indicators of IT investment intensity, IT investment per factory which has a high growth rate of more than 12 perecnt, has a very large size effect, due to the increasing presence of large sized firms, this may not essentially represent an actual increase in the intensity of IT use. The indicator, IT investment per worker, has grown at four percent per annum mainly due to declining employment and rising capital labour ratio. IT investment as a share of total investment, however seem to be declining. When compared to adoption rates, which grew at 7.5 percent these two indicators, seem to be stagnant or at best growing very slowly. ***Thus while IT adoption seem to be spreading at a fairly rapid pace in the Indian manufacturing sector, IT investment intensity seem to be stagnant.***

To have an understanding of the present levels of IT investment a comparison of these figures with that of the OECD countries is attempted (table 5). For a comparable year, in 1999 the IT investment as a share of total investment of the OECD countries ranged from 16 percent to 36 percent, while that of India, for the year 1998-99, the figure was just 6.77 percent. All these developed economies had already achieved an IT investment-

GFCF ratio of at least more than 7 percent by 1980, which was approximately the Indian figure in 1998-99 suggesting a lag of nearly two decades. Such differences in IT investment are quite glaring even when we compare the Indian performance with that of other developing middle-income countries such as Brazil (Basant et .al, 2007). This corroborate the empirically tested link between level of economic development and IT investment (Pohjola, 2003). Given the extent of the lag in IT diffusion in India compared to the developed economies the professed gains from the use of IT may also reach India and other developing economies at such a lag, which essentially connotes that the IT diffusion divide and its effects in terms of Industrial productivity, and growth would exacerbate inequalities of varied forms.

Table 5: Share of ICT in total investment: Some Comparisons

Year/Period -	Germany [12]	France	Italy	Finland	Japan	USA	Australia	India [13]
1980	11.8	8.2	9.6	9.5	7.2	15.2	7.6	-
1990	14.0	9.8	13.7	14.9	12.4	22.5	13.7	-
1995	13.3	11.5	14.4	30.0	15.9	26.1	19.3	-
1999	16.2	16.0	16.3	36.0	17.9	31.7	20.8	-
1998-99	-	-	-	-	-	-	-	6.72
1999-00	-	-	-	-	-	-	-	11.82
2000-01	-	-	-	-	-	-	-	9.94
2001-02	-	-	-	-	-	-	-	10.50

Source:-OECD (2001), Jeong, Oh and Shin, (2001), Annual Survey of Industries

Inter-industry variation

An analysis on inter–industry variation in IT diffusion is instructive as the literature tends to suggest that the observed rate of diffusion, among other factors, is influenced by the industry characteristics. Does these findings confirms to the evidence from India's manufacturing sector? The indicators tend to suggest that the inter-industry variation do exist but the variation has been continuously declining over years as is evident from the estimated values of the coefficient of variation (CV). (from 40.6 percent in 1998-99 to 26.7 percent in 2004-05) This trend , along with the rise in average IT adoption rates ,

[12] For Germany, France, Italy, Japan, Finland, USA and Australia the ratio expressed is IT investment as a share of total investment in the business sector, which includes the manufacturing sector.
[13] For India the figure relates to the IT investment as a ratio of total investment in the manufacturing sector.

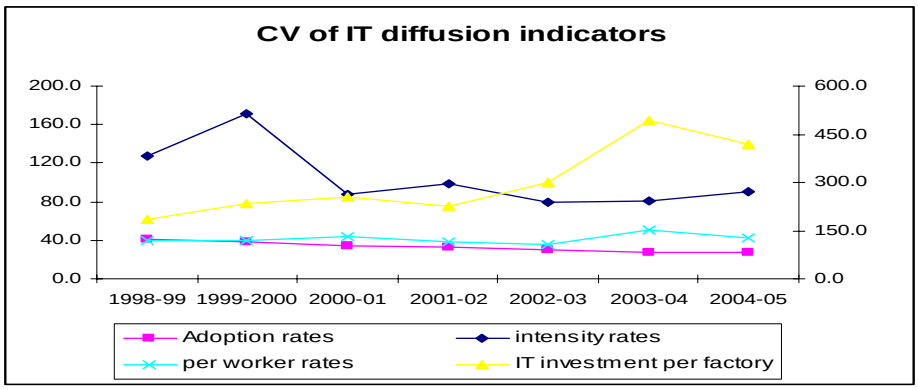
points to the fact the IT adoption is increasing over the years and the inter industry variations are declining.

However, all other indicators of IT diffusion, which are indicators of IT use rather than simple adoption, have a much larger variation across industries. For instance the CV for IT investment share in GFCF rates were 127 percent , IT per worker rates were 120.5 and IT investment per factory were 184.2 percent; compared to the CV of adoption rates of 41 in the year 1998-99.

The CV of IT investment share in GFCF declined during the period from 127 percent to 91 percent, indicating declining trends in inter-industry variations. However this convergence in the share of IT investment in GFCF had occurred during a period when the average share of IT investment in GFCF had been by and large stagnant and the growth rates of this indicator had been negative. ***The convergence in the IT investment share in GFCF is thus due to the decline in the average IT investment across industries rather than industries with low investment intensity catching up with high investment intensity industries.***

Table 6.: Coefficient of Variation in different indicators of adoption across Industries (%)

	IT Adoption rates	IT share in GFCF	IT per worker rates	IT investment per factory	Real NVA per Factory
1998-99	40.6	126.8	120.5	184.2	164.8
1999-2000	38.5	170.6	120.4	233.4	170.7
2000-01	34.0	87.5	133.0	254.1	154.2
2001-02	32.3	98.8	114.6	225.3	130.6
2002-03	30.3	80.0	107.8	299.3	142.2
2003-04	27.8	80.4	151.6	493.3	146.1
2004-05	26.7	90.8	127.9	420.5	141.9



However, the IT investment per unit of worker and IT investment per factory shows a diverging trend over time. The CV for IT investment per worker increased from 121 to 128 and that of IT investment per factory increased from 184 to 421. These two indicators had been growing at high rates, as mentioned above. However, given that the inter-industry variations in these two indicators had been widening, one could infer that growth in these two indicators had been relatively industry specific. However, given the fact that inter-industry variation in average size of firm is declining, as can be seen from the declining CV of Real NVA per factory, the size effect may not explain the rising CV of IT investment per factory. Rather than size effect the growing variations seem to be industry specific, wherein, in some industries the IT investment per factory is growing faster than the others.

This mismatch between IT adoption rates and indicators of IT investment comes out clear when a correlation coefficient is drawn between IT adoption rate and the IT investment indicators (see table 7). The correlation between adoption rates and all indicators of IT only two indicators that show high levels of correlation is between IT investment per employee and IT investment per factory, 0.68.

Table 7: Correlation between different Indicators of IT Diffusion

	Adoption Rate	IT inv. share in GFCF	IT inv. Per employee	IT inv. Per Factory	IT Share in GFCF	IT inv. Per employee	IT inv. per Factory	Employee	IT inv. per Factory

1998-99		0.221	0.362	0.336		0.514	0.152		0.62
1999-00		0.352	0.427	0.273		0.141	0.150		0.67
2000-01		0.294	0.575	0.250		0.371	0.130		0.61
2001-02		0.381	0.510	0.294		0.574	0.216		0.61
2002-03		0.308	0.546	0.339		0.361	0.097		0.56
2003-04		0.437	0.364	0.124		0.583	0.450		0.88
2004-05		0.416	0.425	0.128		0.489	0.181		0.78
Total		0.295	0.450	0.174		0.348	0.153		0.68

Source: Annual Survey of Industries, CSO

use is quite weak. The correlation between adoption rates and IT investment share in GFCF is at 0.29, while with IT investment per worker is at 0.45 and with IT investment per factory is at 0.174. It needs to be recognized, from these trends that while adoption rates are increasing at a fast pace, the levels of use of IT, or the intensity in IT use is not increasing at the same rate. The rise in adoption rate of IT for now, seems to be in the non-core processes of the manufacturing sector, which require low levels of investment intensity. This is corroborated by the fact that IT investment share in GFCF in the manufacturing sector had been largely stagnant through out the period. The average level of correlation between IT adoption rates and IT investment share in GFCF though very low at 0.29 there are signs of increasing correlation which increased from 0.221 to 0.416 during the period.

Table 8: IT Diffusion as 2 digit level of aggregation

nic2dig	Adoption Rate	IT investment Per Worker	share of IT investment in GFCF	IT investment per Factory
Wood and Products of Wood	16.8	574.9	5	0.1
Tobacco Products	16.6	309.8	7.3	0.5
Tanning and Dressing of Leather Luggage,	44.9	923.6	4.8	0.6
Textiles	41.1	1296.3	4.2	0.8

Fabricated Metal Products, Except Machinery	45.3	2369.3	10.4	0.9
Food Products and Beverages	25.2	1204.4	3.7	0.9
Paper and Paper Products	51.5	1960.4	2.8	1.0
Rubber and Plastic Products	51.4	2245.7	4.5	1.0
Wearing Apparel Dressing and Dyeing of Fur	62.1	1322.7	12.1	1.2
Other Non-Metallic Mineral Products	18.7	1847.9	2.8	1.3
Furniture; Manufacturing N.E.C.	50.1	3340.4	12.2	1.7
Machinery and Equipments N.E.C	58.2	4431.5	12.8	2.2
Basic Metals	49.2	2819.9	4.3	2.2
Electrical Machinery and Apparatus N.E.C.	65.1	3947	10.3	2.4
Other Transport Equipment	60.9	3354	13	3.3
Medical & Optical Instr's, Watches and Clocks	66	8335.2	22.9	5.0
Chemicals and Products	56	3995.6	11.9	5.9
Publishing, Printing and Reproduction etc	53.7	10294.7	17.7	6.6
Coke, Petroleum Products and Nuclear Fuel	49.1	7637.1	1.8	7.7
Radio, TV & Communication Eqpts & Apparatus	71.1	9560.9	11.9	9.8
Office, Accounting and Computing Machinery	74	17276.8	16.6	17.3
Motor Vehicles, Trailers and Semi-Trailers	63.1	10299.7	9	49.7
Total	42.1	4418.8	9.5	5.6

The weak correlation between share of IT investment in GFCF and IT investment per factory support the earlier argument that high rates of IT investment per factory is due to the size effect, and not necessarily a manifestation of higher IT investment intensity. A summary picture for the entire period of seven years is given in table 8. The IT adoption rates are the lowest in Tobacco industry, where the adoption rates are only 17 percent. IT investment per worker is also the lowest in the Tobacco industry. On the other hand IT adoption rates were as high as 74 percent in the Office, Accounting and Computing Machinery. This industry also accounted for the highest IT investment per worker at Rs. 17276 per worker.

To bring out the position of industries in terms of IT investment intensity relative to that of IT adoption rates we have mapped the industry position in the IT investment intensity relative to adoption rates. As can be seen from Chart below, the distribution of industries with different levels of IT adoption rates and IT investment rates are varied. While in general the industries with low adoption rates have low IT investment intensity and high adoption rates are associated with high intensity as well, there are a sizeable number of industries that do not follow the norm.

For example Textile industry which has a high adoption rate of more than 41 percent, its investment intensity rate is only 4.2 percent. Similarly, Tanning and leather industry has an adoption rate of more than 45 percent while the IT investment intensity is as low as 4.8 percent, For petroleum industry, the adoption rate was as high as 49 percent but the investment intensity was just above 1 percent. Basic Metal and Rubber & plastic industries had also high adoption rates along with very low investment intensity rates. In these groups of industries the trends suggest that IT adoption has taken place, without any substantial investment in IT.

There are another set of industries where the IT investment intensity is very high but the IT adoption rates are quite low. Tobacco industry and wood industry, for example have IT adoption rates at less than 17 percent while IT investment intensity was at 7.3 and 5 percent respectively. Such trends in these industries reflect the dualistic nature of the

Table 9: Level of IT Adoption Rate and IT investment share in GFCF

IT investment share in GFCF (%)					
IT Adoption Rates (%)		less than 5	5 to 10	10 to 15	greater than 15
	less than 20	Other Non-Metallic Mineral Products	Tobacco Products Wood and Products of Wood		
	20 to 40	Food Products and Beverages			

	40 to 60	Textiles; Tanning and Dressing of Leather Luggage, Coke, Petroleum Products and Nuclear Fuel Basic Metals Rubber and Plastic Products	**Average**	Fabricated Metal Products, Except Machinery Furniture; Manufacturing N.E.C. Chemicals and Products Machinery and Equipments N.E.C	Publishing, Printing and Reproduction etc
	greater than 60		Motor Vehicles, Trailers and Semi-Trailers Radio, TV & Communication Eqpts & Apparatus	Other Transport Equipment Wearing Apparel Dressing and Dyeing of Fur Electrical Machinery and Apparatus N.E.C.	Medical & Optical Instr's, Watches and Clocks Office, Accounting and Computing Machinery

industry. In these industries there seem to be a set of factories that invest heavily in IT after their adoption, while the rest of the firms have not even adopted IT.

Table 10 provides a comparison of IT investment share in total investment between India and USA for various manufacturing sectors. The Table shows the average IT investment share of GFCF for India during the period 1998-2005, the average for the period 2002-2005 and for U.S.A, for the year 1990. Even though the data gap between the two economies is nearly that of two decades, the gap in IT intensity between India and U.S. is conspicuous. Such differences in the IT investment intensity are highest in the case of the technology intensive sectors such as Office and computing machines; Electrical apparatus industries and Motor Vehicles industries. For instance, in office and computing machines sector, one of the most IT intensive sectors across the world, the Indian figure was nearly 17 percent in 1998-2005 , while that of U.S. was nearly 35 percent as back as in 1990. In Electrical apparatus, U.S. had an IT intensity of nearly 44

Table 10: IT investment share of GFCF: Comparison of Industries

ISIC Rev. 2	India		USA
	1998-2005	2002-2005	1990
1. Food, beverages & tobacco	4.3	4.0	6.76
2. Textiles, apparel & leather	6.6	6.1	10.18
3. Wood products & furniture	8.6	8.4	6.32
4. Paper & printing	14.0	14.5	16.16
5. Industrial chemicals	11.9	5.5	12.82
7. Petroleum & coal products	1.8	1.8	3
8. Rubber & plastic products	4.5	4.0	7.27
9. Non-metallic mineral products	2.8	3.1	4.59
10. Iron & steel	4.3	4.7	11.98
12. Metal products	11.9	12.1	12.3
14. Office &computing machines	16.6	6.7	34.98
15. Electric apparatus, nec	14.5	14.7	43.92
16. Communication equipment	11.9	12.8	14.09
18. Other transport	13.0	13.3	4.65
19. Motor vehicles	9.0	11.2	22.49

Note: The data pertaining to USA was adopted from Surendra et al(1998)
Source: calculated from data obtained from ASI, CSO; Surendra et al(1998)

percent, for which the corresponding figure for India was 15 percent. Moreover, though there are considerable inter-industry variations in IT investment intensity in the U.S. as well in all the industries, except for other transport and Wood product and furniture, the U.S. 1990 figures are higher than the corresponding Indian figure nearly decade later. Thus the digital divide that exists between a developing economy like India and the U.S. is quite conspicuous.

Concluding observations

India's experience with the Information Technology as a sector has been at variance with it as a general purpose technology. While the production of Information technology has achieved great heights, through an export oriented strategy, the use of IT in the economy, especially in the manufacturing sector is yet to reach the desirable levels. Following the broader approach to innovation system, we have explored the apparent paradox in India's performance as a leader in production and laggard in diffusion. It was transpired that

India has a vibrant innovation system most conducive for the development of an IT sector. The innovation system evolved over the years, has also facilitated major structural transformation of the IT sector- from an onsite provider of IT services to operations mainly offshore, from focus on low end of the value chain to value added services, software products and embedded software indicating significant building up of technological capability and remarkable export growth. However, a close examination of the different elements of the innovation system as evolved in India tended to suggest that certain elements of the innovation system operated especially against its wider diffusion across different sectors of the economy

Our empirical analysis confirmed the above hypothesis. It was found that while the adoption rates of IT increased steadily in the manufacturing sector wherein more than half of the plants have adopted IT by 2004-05. The rise in IT adoption notwithstanding, the intensity of IT use, measured as different indicators of investment in IT have been more or less stagnant at low levels. The stagnation in IT investment as a share of gross fixed capital formation, in comparison to developed economies, may further widen the already existing digital chasm and its adverse effects, including productivity and competitiveness. Also, the lack of any significant correlation between IT adoption and IT investment indicators brings out the very peripheral nature of IT use in the manufacturing sector. Adoption of IT in the sector, it appears is not geared towards greater use of IT in the core areas of production.

Further, the widening inter-industry variations in IT investment per worker and per factory, despite a convergence in IT adoption rates, indicate the growing industry specificity of the technology that needs further exploration. Stagnant IT investment intensity notwithstanding in some of the technology intensive sectors both the adoption rates and IT investment intensity had been very high. The IT investment share in GFCF, despite being very low in comparison to developed economies, at least in a few sectors the gap between US and India had been declining. But this convergence had been mostly in industries with low levels of IT investment intensity. In industries with high IT investment intensity the gap is very large.

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